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Specification and Drawings, as originally filed, with Application for Patent Serial No: **2,404,535**, on September 20, 2002, by **SERGE MOREAU**, for "Composite Floor System".

Agent certificateur/Certifying Officer

October 31, 2003

Date

B216-10

ABSTRACT

In a composite floor system, the end support shoe of a secondary framing member can provide a shear connector for a primary steel framing member, such that the secondary member and its end shoe provide the horizontal shear connection for the primary member. the end shoe of the secondary members are welded to the primary members which can be either standard steel beams or open web trusses. The secondary members are preferably open web joists having their own s-shaped top chord to provide shear connection of the secondary members with the slab. Accidental tripping of steel workers on shear studs is avoided.

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COMPOSITE FLOOR SYSTEM

Field of the Invention

The present invention relates to composite steel and concrete floor systems, and in particular to reinforced concrete slabs supported by primary steel framing members, such as hot rolled steel beams, girders, or trusses, and secondary framing members such as open web steel joists. In such structures, it is efficient to couple the concrete and steel components to provide composite action, thereby reducing the amount of material in the floor system for a given required strength. By using the concrete slab as the top chord of a composite beam, a significant reduction in the amount of steel in the floor system is achieved. Such floor systems are known in the art, one well known system of secondary members is sold as the Hambro™ structural system.

Background of the Invention

In residential buildings it is possible to arrange the structure to span open web joists between load bearing walls, and no primary framing members are required to support the joists. In larger structures, the joists must be supported by primary framing members in the form of steel beams or trusses. This is particularly the case for steel framed buildings which are erected as steel columns connected by and supporting primary steel framing members. Secondary steel framing members in the form of open web steel joists are spanned across the primary members, and loads are transferred by the primary members to the columns, and to the foundations of the

building.

Many forces must be resisted by the structure, both horizontal and vertical, and the design of such structures is complex, requiring the application of much scientific skill and knowledge. One of the forces encountered in these structures is known as horizontal shear. This is a horizontal force which occurs along the longitudinal top of primary and secondary frame members. The Hambro open web joist is provided with a unique s-shaped top chord which when embedded in the concrete slab forms a shear connector to prevent slippage from occurring between the concrete slab and the joist due to horizontal shear along the joist.

Various forms of shear connector have been developed for steel beams, the most common is the headed shear stud, or Nelson stud, an elongated vertical device, which has an enlarged head, much like an oversized nail. This stud is welded to the steel beam after the beam has been connected to the structure during erection. This stud provides the necessary shear capacity between the embedded stud and the concrete slab thereby providing a composite steel beam or girder. The stud is intended to be imbedded in the concrete and transfer horizontal shear forces from the slab to the beam. The most cost effective way to provide shear studs is to install them in the shop.

A serious problem exists with this shear connector. These studs constitute a tripping hazard for steel workers who have to walk on these beams during erection of the frame. The seriousness of the problem is highlighted by the fact that for more than 25 years the International Ironworker agreement has rejected the use of such studs on steel beams. These rules were adopted by safety committees as they were formed in Canada and the USA, such as OSHA. When composite construction

is used, the studs need to be welded through the metal decking on the steel top chord, after the open web or full web steel joists have been placed on the primary steel member and after having installed the steel deck. Site installing shear studs creates quality problems due to the very nature of the welding process. While installing these components is weather dependant, these speciality elements are difficult to schedule in a fast paced structural steel erection program. Thus there is a need for a new form of shear connector for the beam which leaves the top flange essentially flat for walking by steel workers, and avoids the installation and scheduling problems.

Statement of the Invention

The present invention forms a shear connection for primary frame members which does not create a tripping hazard during erection and prior to the composite stage when the concrete floor slab has been formed and is cured, which effectively transfers horizontal shear forces to the primary frame members.

In one aspect the present invention is directed to a composite floor system, providing inter alia all the advantages of composite steel/concrete floor slab construction, with the added advantage of an efficient horizontal shear connection to primary steel floor members, allowing a continuous poured slab for an entire floor of a building to be formed with no tripping hazards for iron workers, due to shear connectors. Such a structure will also be designed by structural engineers to meet all other loads encountered in usual building construction.

In a further aspect, the present invention provides a method of assembling the steel members prior to concreting,

and the present invention further provides a new end shoe for connecting the joist to the beam. The invention also provides a novel joist with an end shoe which serves as the shear connector for the beam to which it is attached.

In a further aspect, the present invention provides a framing system for a composite steel and concrete floor comprising primary steel framing members supporting secondary steel framing support members, the secondary members having continuous shear connection to the concrete floor when embedded therein, the secondary steel members having end shoes welded to the primary members, the end shoes providing a shear connection between the concrete floor and the primary members.

In a further aspect, the present invention provides a method of erecting a framing system for a composite steel and concrete floor comprising placing primary framing members in parallel relation, placing secondary framing members having end shoes spanning between the primary members, and welding the secondary members end shoes to the primary members to provide a shear connector for the primary members.

In a further aspect, the present invention provides an end shoe for an open web joist intended to be used as a secondary member in a composite steel and concrete floor comprising a shape having one face adapted to be placed in contact with a primary frame member, and a second face fastened to the secondary member.

Brief Description of the Drawings

Figure 1 is an overhead perspective of a composite floor in accordance with the present invention, with the concrete slab partially removed to show the steel frame members;

Figure 2 is a cross-section through a floor system of

the invention perpendicular to a primary framing member;

Figure 3 is a cross section at right angles to the section of Figure 2;

Figure 4 is a sectional view of the mounting of secondary frame members in the form of open web steel joists on a primary steel beam member;

Figure 5 is a sectional view of a primary frame truss supporting open web steel joists;

Figure 6 is an enlarged perspective of the frame members of Figure 5;

Figure 7 is an end elevation of a frame truss or joist girder for use in the floor system of the invention;

Figure 8 is an end elevation of the joist truss supporting two joists of the present invention;

Figure 9 is an plan view of the joist truss supporting a plurality of open web joists of the invention;

Figures 10 and 11 are side elevations of two joist truss girders for use in the present invention, and

Figure 12 is a plan view of a primary frame steel beam supporting staggered open web steel joist secondary frame members, with end shoes welded to the beam.

Detailed description of the Invention

Referring to Figure 1 there is shown in perspective an overhead view of a composite floor system of the invention. A primary frame member 11 which is shown here as a steel truss or girder, supports a plurality of secondary frame members formed as open web steel joists 12 which span perpendicularly between adjacent primary members (not shown). Each joist is provided with an end shoe 13 on each end of the joist for attachment to the primary member. Figure 6 shows this in greater detail as explained below. Preferably, the joist used

is a Hambro joist provided with an s-shaped top chord which forms a shear connector between the joist and the concrete slab. A concrete slab 14 with reinforcing mesh 15 is poured onto form-work (not shown for simplicity) and embeds the top chords 16 of the joists 12 and the top chord 17 of the primary member 11. The end shoes of the joists are welded to the horizontal flange or flanges 18 of the primary member11.

Figure 2 shows a steel beam 11' supporting a joist 12 fitted with an end shoe 13 welded to the beam 11'. This weld is shown in greater detail in Figure 6 below. The end shoe 13 is also referred to hereinafter as a "shear shoe".

In Figure 3 the same beam as shown in Figure 2 is shown in elevation, with the arrow 20 indicating the direction of the horizontal shear force. The combination of the joist 12, the end shoe 13 and the welding of the end shoe 12 to the primary member 11.creates a shear connector to resist the horizontal shear forces between the slab 14 and the primary member 11 or 11'.

The advantages of this new shear connector are many. First, there is the utilization of the joist end shoe designed and analysed to provide a bond included in each secondary framing member. The shear shoe performs a double function of supporting the gravity load on the joist and also provides a mechanical shear connector able to transfer the bond between the slab and the primary member. This type of shear connection also avoids the tripping hazard on the site according to labour union rules, and increases erection speed of the steel building frame.

The present invention features the use of special end or shear shoes which act as shear connectors to the flange of a steel beam or the top chord of a truss. The shoe is also a gravity shoe for the steel secondary framing member and shear

connector tested and designed according to the capacity required for the composites trusses. The welding between the top chord of the truss or beam forming the primary frame member and the shoe is designed according to the capacity required. The open web joist of the secondary members can be used in a deck-slab system such as Hambro MD2000 system or with a removable plywood system such as Hambro D500.

Dependant on the loading and span of the primary member, single shear connectors can be used, or groups of connectors. The total capacity in bond will be the total capacity of all shoe connectors.

Figure 4 illustrates a pair of open web joist secondary members 12, which may be aligned or staggered , mounted on a primary member 11. Each joist 12 is provided with a dual purpose shear shoe 13 which is welded to the joist 12 in manufacture, and delivered to the job-site ready for installation. Each shoe 13 is then welded to the top flange of the regular beam primary member 11. Similarly, Figure 5 illustrates a pair of joists 12 with shear shoes13 mounted on a truss primary member 11. As before the shoes are welded to the top flanges of the truss 11. In both of these cases horizontal shear between the primary member and the slab is transferred from the slab to the primary member by the shear shoes 13.

Figure 6 is a perspective from above of the connection of the secondary open web joists 12 and the primary member truss 11. Welds 21 are provided on both sides of shoes 13 to fix the shoes 13 to the top flanges of the truss 11.

Figure 7 is a vertical section of a steel primary member truss 11 consisting of a bottom chord formed of angles 30 welded back-to-back between web members 31 which in turn are welded to a gusset plate 32 which in turn is welded to a

pair of back-to-back top chord angles 33. The vertical legs of the angles 33 are slotted at intervals, the slots being staggered, and rod segments 34 are welded to the vertical legs of the angles 33. This novel truss construction provides a strong, light primary member with maximum openings in the web through which building services such as heating, plumbing, electrical, and communication services can be located. Figure 8 shows the connection of primary and secondary members using the truss of Figure 7, integrating the whole frame structure to resist horizontal shear forces, and support the gravity load of the floor system.

Figure 9 is a plan view of a portion of a floor frame system10 including a primary truss 11 secondary joists 12 with end shoes13, in which the joists are aligned rather than staggered.

Figures 10 and 11 show alternate truss configurations depending on building requirements, Figure 10 being the standard configuration and Figure 11 being a configuration for maximum size openings in the truss for accommodating large ducts.

Figure 12 is a plan view of a steel beam primary member 11 supporting staggered secondary open web joist members 12 with shear shoes 13 welded to the member 11. Such staggering of the secondary members is required when shear connectors are required at intervals less than the normal joist spacing.

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I claim:

1. A framing system for a composite steel and concrete floor comprising primary steel framing members supporting secondary steel framing support members, said secondary members having continuous shear connection to the concrete floor when embedded therein, said secondary steel members having end shoes welded to said primary members, said end shoes providing a shear connection between said concrete floor and said primary members.

2. A framing system as defined in claim 1, wherein said secondary members are provided with a continuous top chord having an s-shaped cross-section.

3. A framing system as defined in claim 1, wherein said end shoes comprise an angle iron having one face parallel said primary member, and the other orthogonal to said secondary member.

4. A framing system as defined in claim 1 wherein said primary member is a steel beam.

5. A framing system as claimed in claim 1 wherein said primary member is a truss.

6. A method of erecting a framing system for a composite steel and concrete floor comprising

placing primary framing members in parallel relation,

placing secondary framing members having end shoes

spanning between said primary members, and

welding said secondary members end shoes to said primary members to provide a shear connector for said primary members.

7. A method as defined in claim 6 wherein said secondary members have a continuous shear connector.

8. A method as claimed in claim 7 wherein said shear connector is a continuous s-shaped top chord adapted to be embedded in said concrete floor.

9. An end shoe for an open web joist intended to be used as a secondary member in a composite steel and concrete floor comprising a shape having one face adapted to be placed in contact with a primary frame member, and a second face fastened to said secondary member.

10. An end shoe as claimed in claim 9 wherein said shape is a right angle with its faces orthogonal to said secondary member.

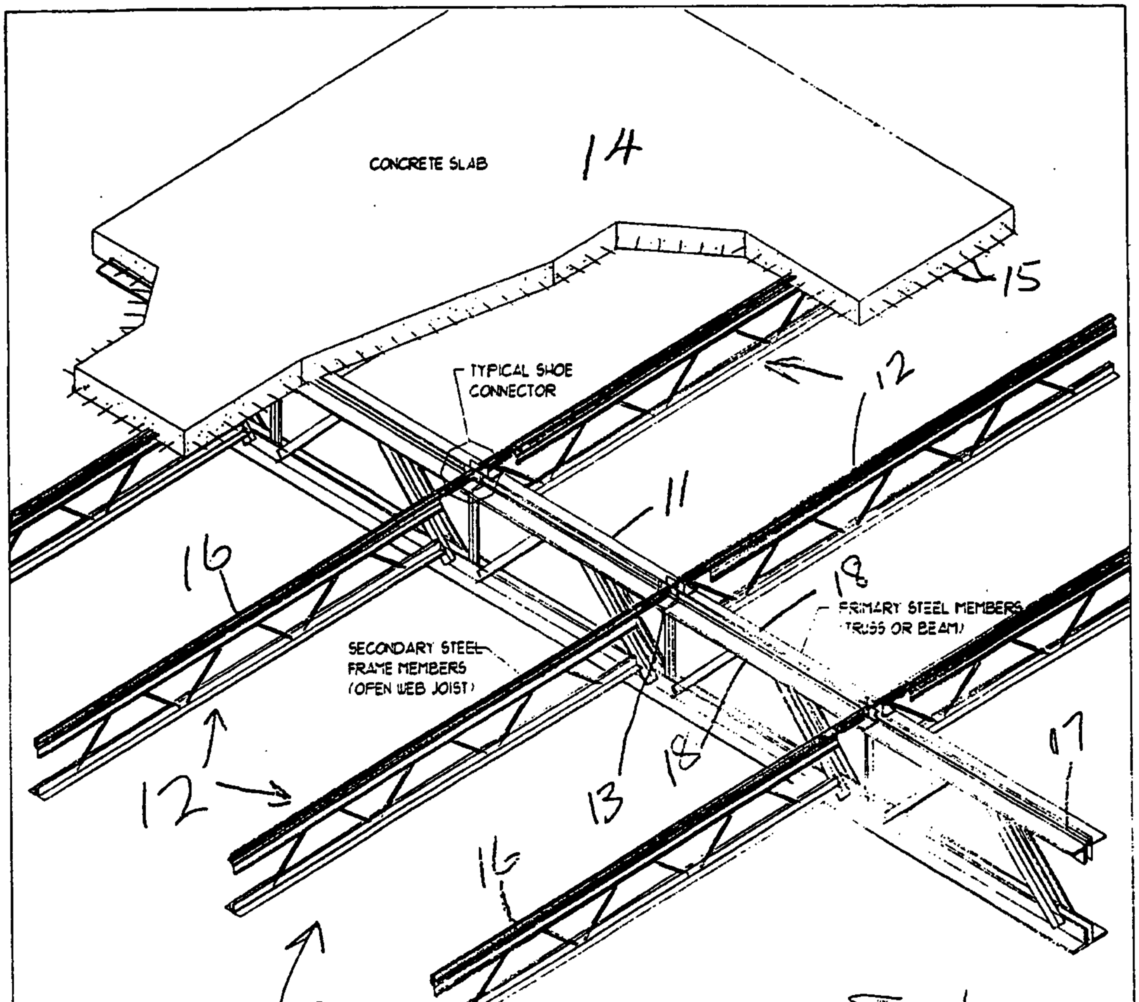

CONCRETE SLAB
14
15
TYPICAL SHOE CONNECTOR
12
11
16
18
PRIMARY STEEL MEMBERS (TRUSS OR BEAM)
SECONDARY STEEL FRAME MEMBERS (OPEN WEB JOIST)
12
13
18
17
16
10

Fig 1

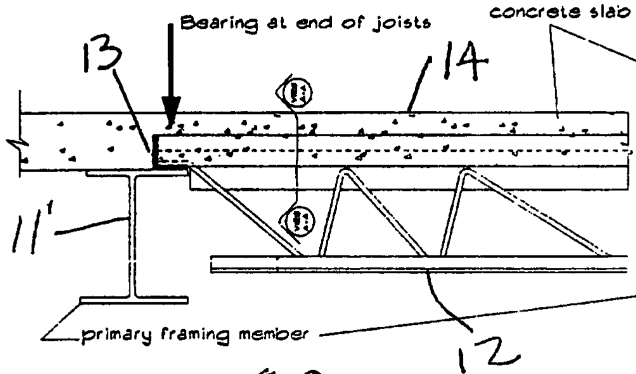

Bearing at end of joists
concrete slab
13
14
11'
12
primary framing member

FIG 2

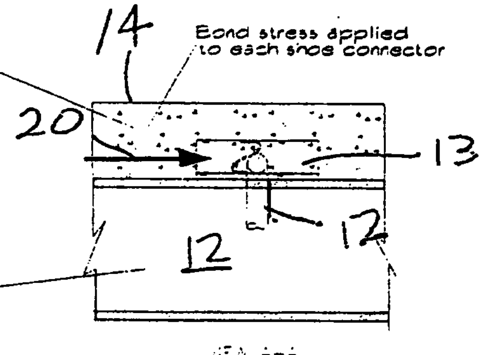
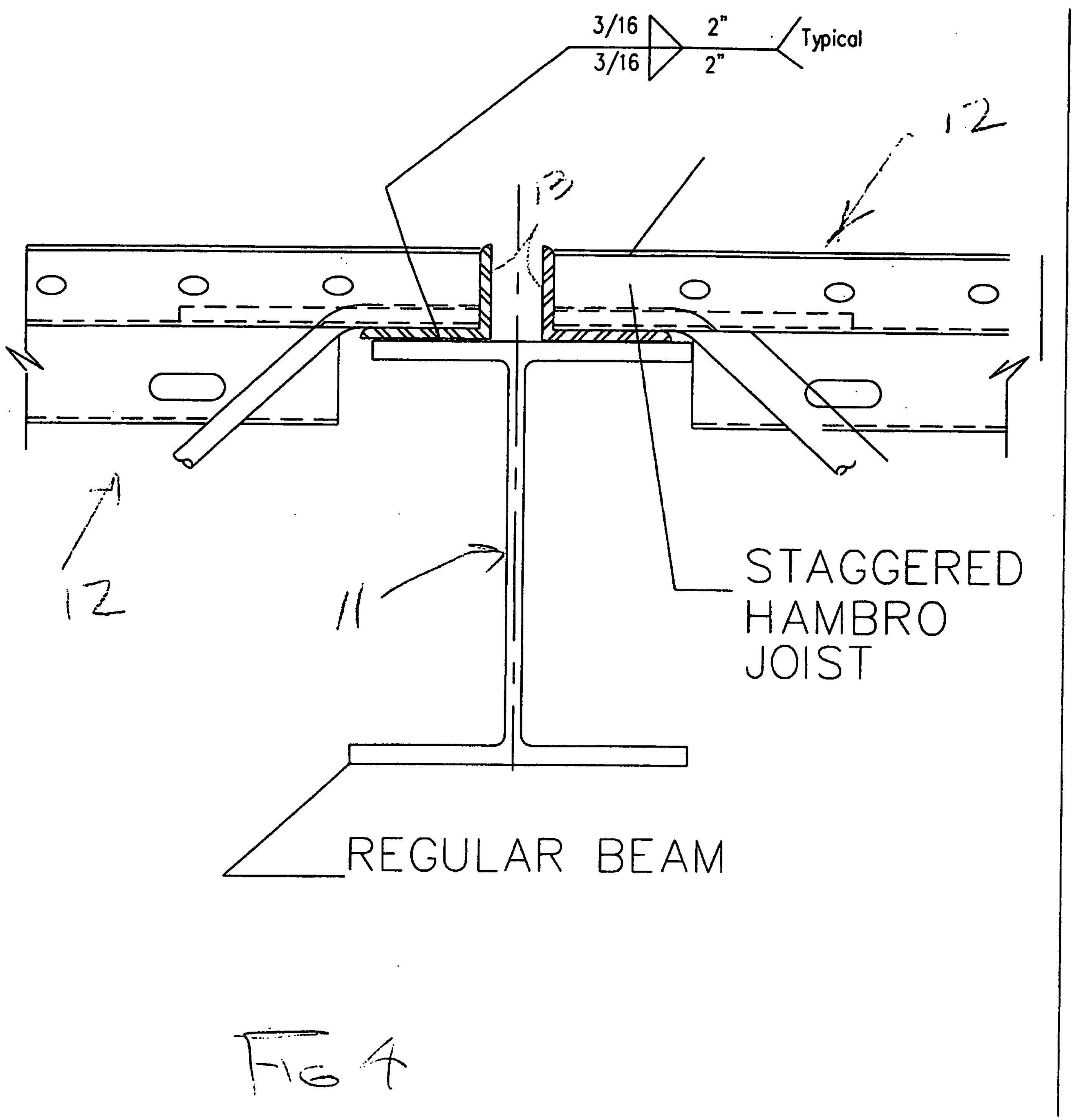

14
Bond stress applied
to each shoe connector
20
13
12
12

FIG 3



3/16
2"
3/16
2"
Typical
12
13
12
11
STAGGERED HAMBRO JOIST
REGULAR BEAM

FIG 4

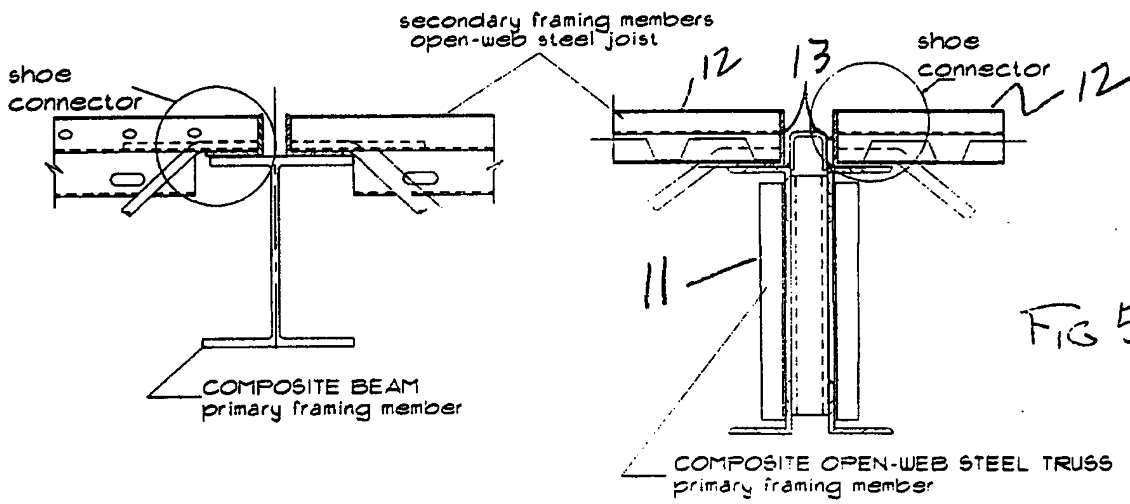

secondary framing members
open-web steel joist
shoe
connector
shoe
connector
12
13
12
11
COMPOSITE BEAM
primary framing member
COMPOSITE OPEN-WEB STEEL TRUSS
primary framing member

FIG 5

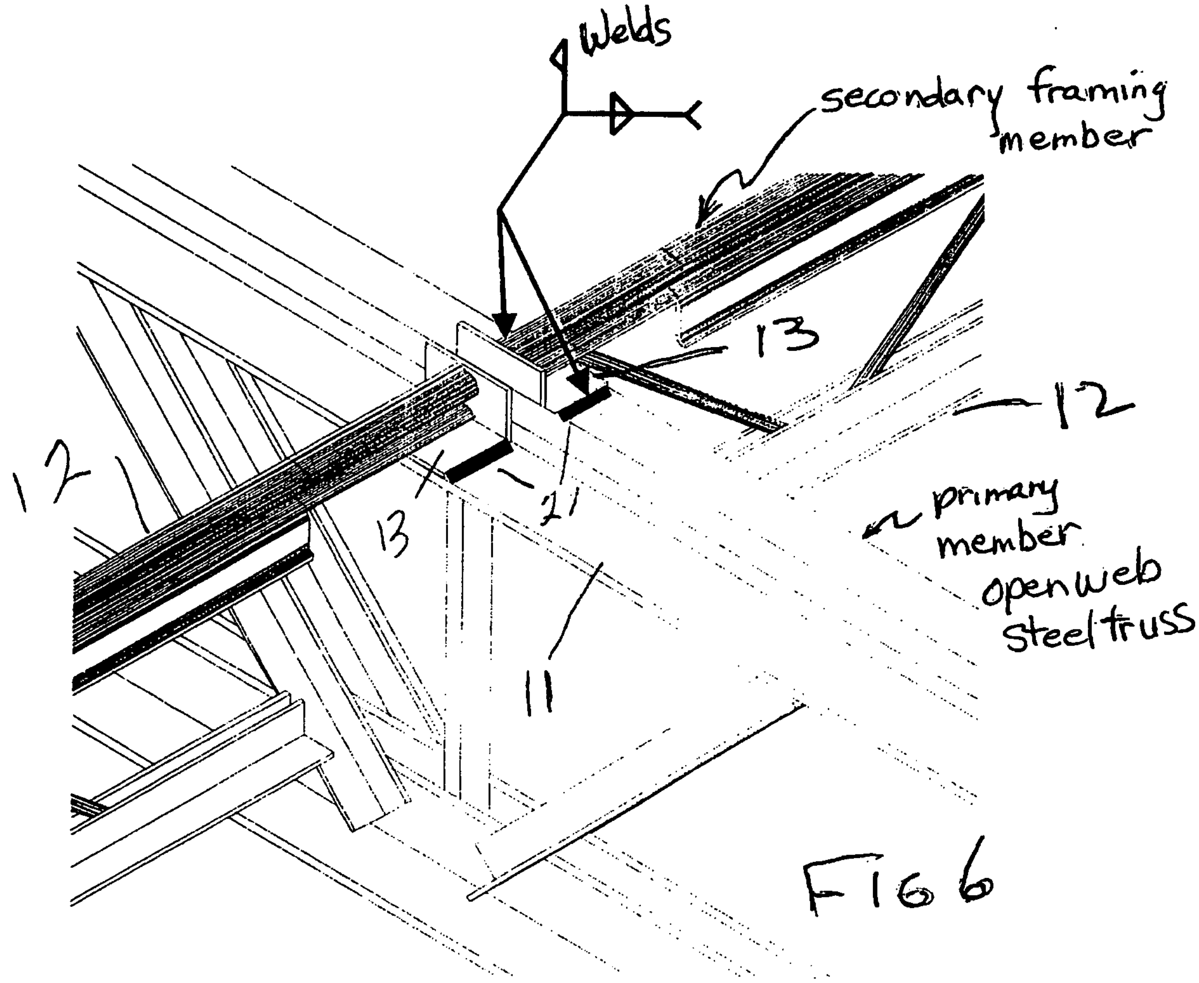
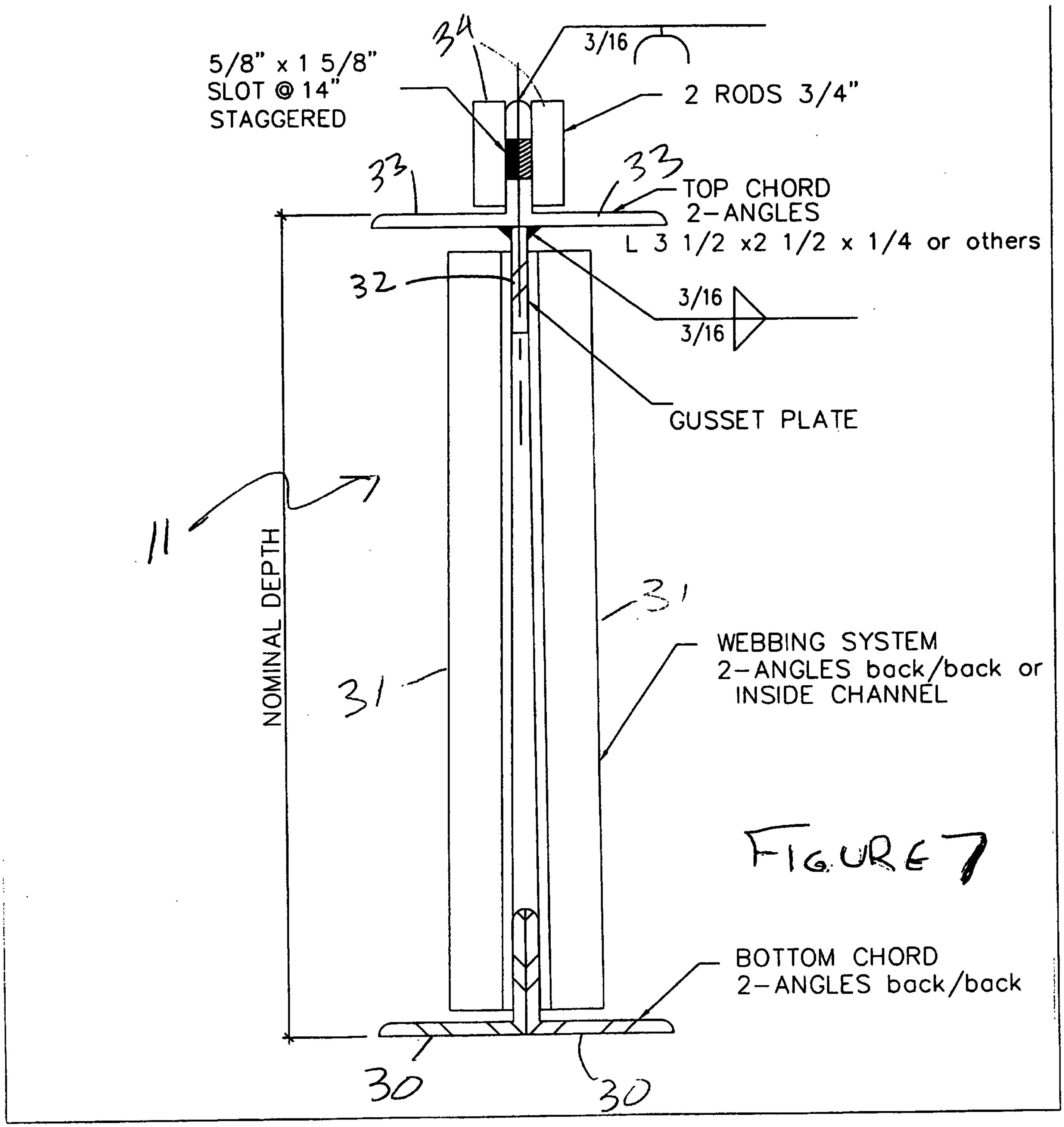
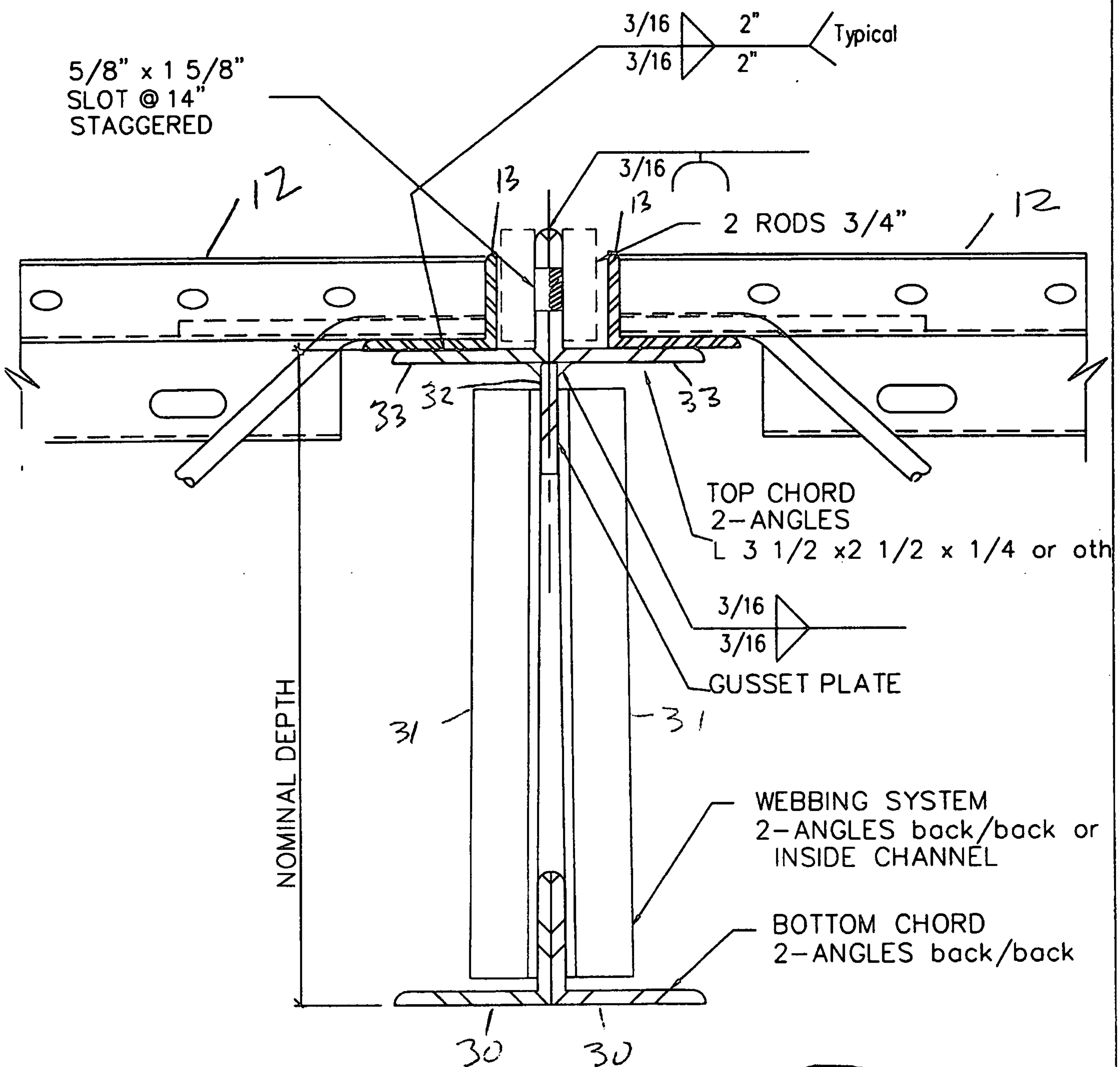

Welds
secondary framing member
13
12
12
13
21
primary member openweb steel truss
11

FIG 6



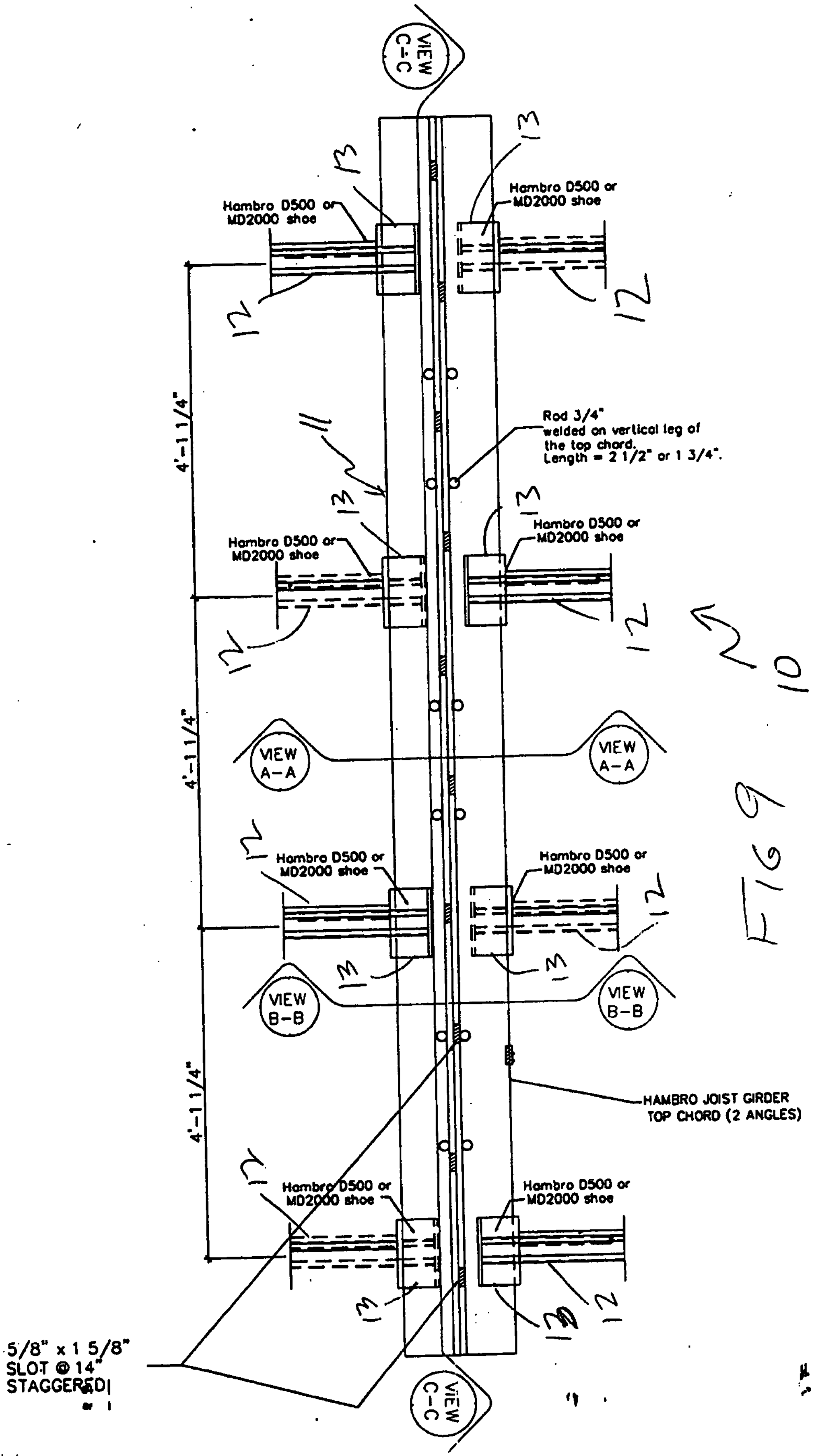
34
5/8" x 1 5/8"
SLOT @ 14"
STAGGERED
3/16
2 RODS 3/4"
33
33
TOP CHORD
2-ANGLES
L 3 1/2 x2 1/2 x 1/4 or others
32
3/16
3/16
GUSSET PLATE
11
NOMINAL DEPTH
31
31
WEBBING SYSTEM
2-ANGLES back/back or
INSIDE CHANNEL
BOTTOM CHORD
2-ANGLES back/back
30
30

FIGURE 7



3/16
2"
Typical
3/16
2"
5/8" x 1 5/8"
SLOT @ 14"
STAGGERED
3/16
12
13
13
2 RODS 3/4"
12
33
32
33
TOP CHORD
2-ANGLES
L 3 1/2 x2 1/2 x 1/4 or oth
3/16
3/16
GUSSET PLATE
NOMINAL DEPTH
31
31
WEBBING SYSTEM
2-ANGLES back/back or
INSIDE CHANNEL
BOTTOM CHORD
2-ANGLES back/back
30
30

FIG 8



VIEW C-C
13
13
Hambro D500 or MD2000 shoe
Hambro D500 or MD2000 shoe
12
12
4'-11/4"
11
Rod 3/4" welded on vertical leg of the top chord. Length = 2 1/2" or 1 3/4".
13
13
Hambro D500 or MD2000 shoe
Hambro D500 or MD2000 shoe
12
12
10
4'-11/4"
VIEW A-A
VIEW A-A
12
Hambro D500 or MD2000 shoe
Hambro D500 or MD2000 shoe
12
13
13
VIEW B-B
VIEW B-B
4'-11/4"
HAMBRO JOIST GIRDER TOP CHORD (2 ANGLES)
12
Hambro D500 or MD2000 shoe
Hambro D500 or MD2000 shoe
13
13
12
5/8" x 1 5/8" SLOT @ 14" STAGGERED
VIEW C-C

FIG 9

STANDARD HAMBRO JOIST GIRDER CONFIGURATION

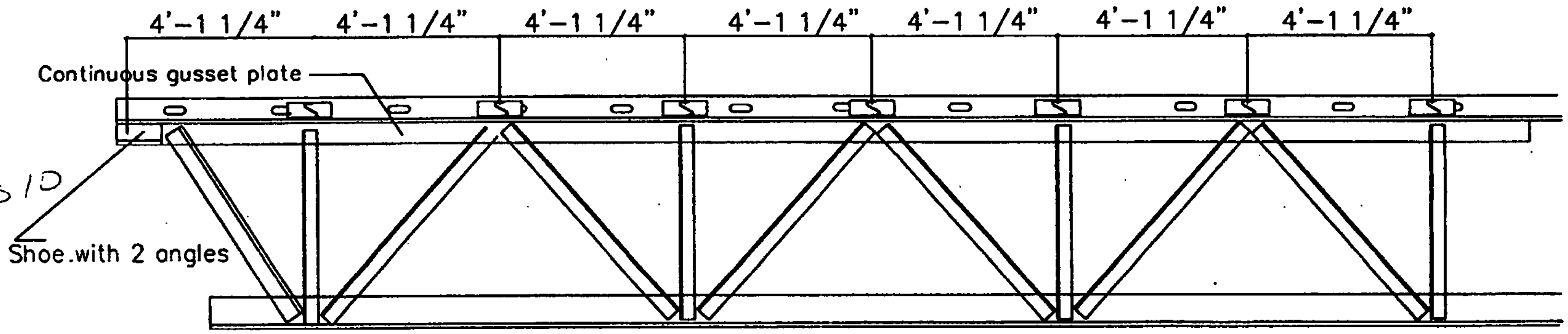


FIG 10

HAMBRO JOIST GIRDER WITH FLUSH SEAT AND GUSSET PLATES

[Used where large duct penetrations are required]

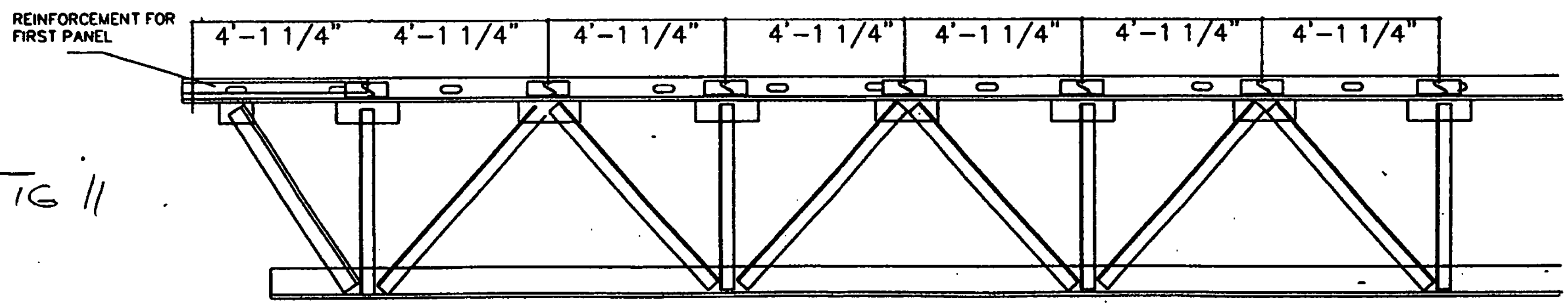


FIG 11

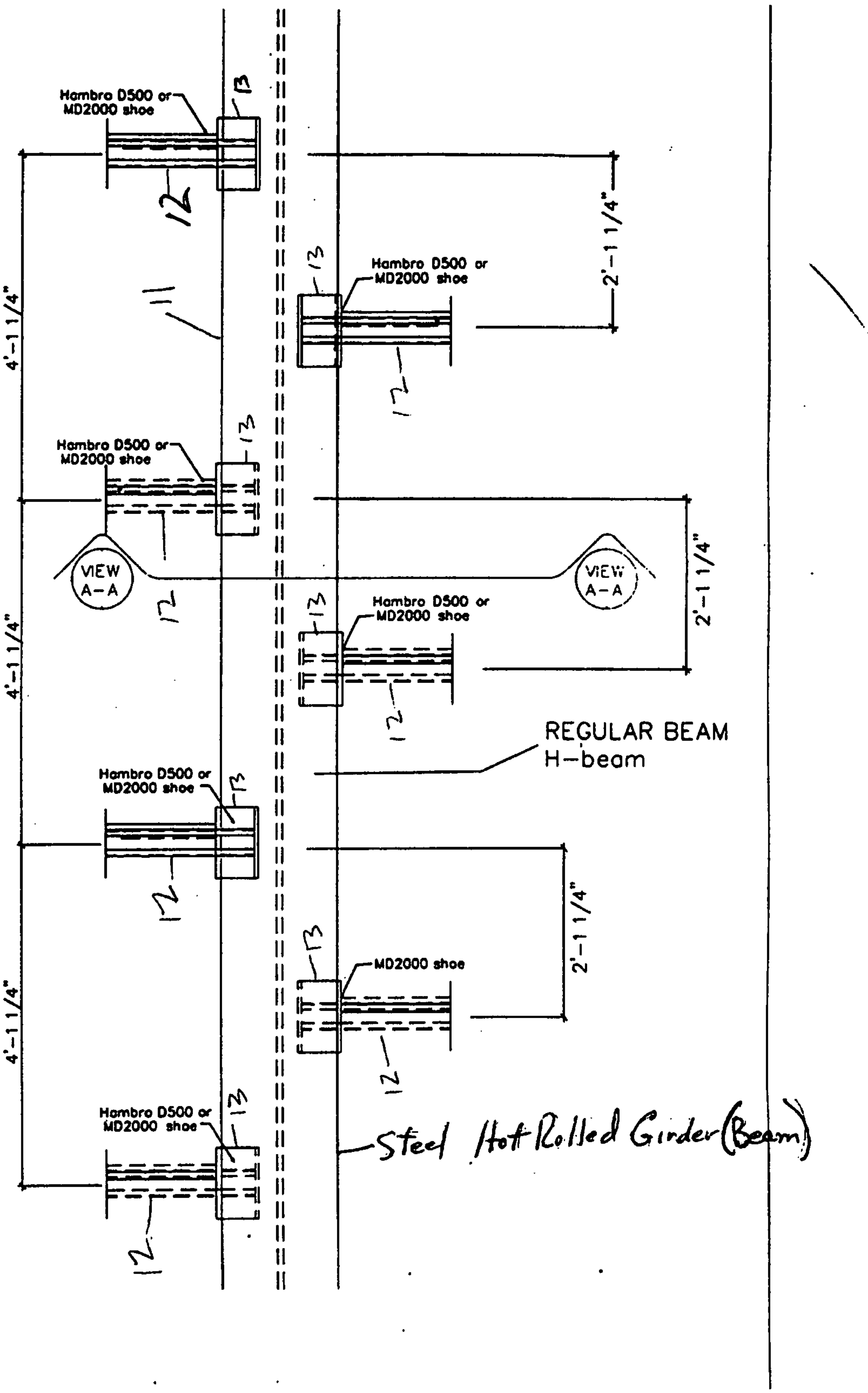

Hambro D500 or
MD2000 shoe
13
12
11
4'-1 1/4"
2'-1 1/4"
VIEW
A-A
REGULAR BEAM
H-beam
MD2000 shoe
Steel Hot Rolled Girder (Beam)

FIG 12